

GEOGRAPHIC DISTRIBUTION PATTERNS OF THE GENUS *ARIOCARPUS* (CACTACEAE) IN TAMAULIPAS, MEXICO

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ABSTRACT

The geographic distribution of the genus *Ariocarpus* in the State of Tamaulipas, Mexico was determined based on literature, herbarium vouchers, botanical gardens and several field trips in 1991 and 1992. Three species and two subspecies were detected: *Ariocarpus agavoides*, *A. kotschoubeyanus*, *A. retusus* subsp. *retusus* and *A. retusus* subsp. *trigonus*. *Ariocarpus agavoides* is extremely restricted geographically, occupying an area less than 2 km²; the main factor responsible for its distribution is soil type, which has clay texture, low organic matter content and a slightly alkaline pH. *Ariocarpus retusus* subsp. *trigonus* has the largest distribution (all the arid and semiarid portions of the state) probably because of its tolerance to different ecological factors, such as vegetation, soil types, and its ability to survive even if nurse plants were removed.

KEY WORDS: *Ariocarpus*, Geographic distribution.

RESUMEN

Se determinó la distribución geográfica del género *Ariocarpus* en el estado de Tamaulipas, México con base en revisiones bibliográficas, consultas de herbarios, jardines botánicos, así como en recorridos de campo realizados en 1991 y 1992. Se encontraron tres especies y dos subespecies: *Ariocarpus agavoides*, *A. kotschoubeyanus*, *A. retusus* subsp. *retusus* y *A. retusus* subsp. *trigonus*. *Ariocarpus agavoides* se encuentra extremadamente restringida geográficamente, ocupando un área no mayor a 2 km²; el factor responsable de su distribución es el tipo de suelo, el cual se caracteriza por su textura arcillosa, bajo contenido de materia orgánica, así como un pH ligeramente alcalino. *Ariocarpus retusus* subsp. *trigonus* presenta el mayor rango de distribución (ocupando las regiones áridas y semiáridas del estado) debido a su tolerancia a diferentes factores ecológicos tales como vegetación, tipo de suelo, y a su sobrevivencia cuando las plantas nodrizas son removidas.

INTRODUCTION

The genus *Ariocarpus* described by Scheidweiler in 1838 (Mitich & Bruhn 1977), is widely distributed in the Chihuahuan Desert (Anderson 1960). This desert is located in the Mexican highlands that includes portions of the states of Texas (U.S.A.) and Coahuila, Nuevo León, San Luis Potosí, Hidalgo, Querétaro, Zacatecas, and Tamaulipas in México (Shreve 1951; Jaeger 1957; Rzedowski 1978; Bravo 1978). In Tamaulipas this region is known as the Tamaulipan Arid Zone (Bravo & Sánchez-Mejorada 1992) including the municipalities (*municipios*) of Tula, Palmillas, Miquihuana, Bustamante and Jaumave (Fig. 1).

The genus *Ariocarpus* includes seven species: *Ariocarpus agavoides* (Castañeda) E.F. Anderson, *A. bravoanus* H. Hernández & E.F. Anderson, *A. kotschoubeyanus* (Lemaire) K.



SYMBOLS	
●	<i>A. agavoides</i>
○	<i>A. kotschoubeyanus</i>
■	<i>A. retusus subsp. retusus</i>
□	<i>A. retusus subsp. trigonus</i>

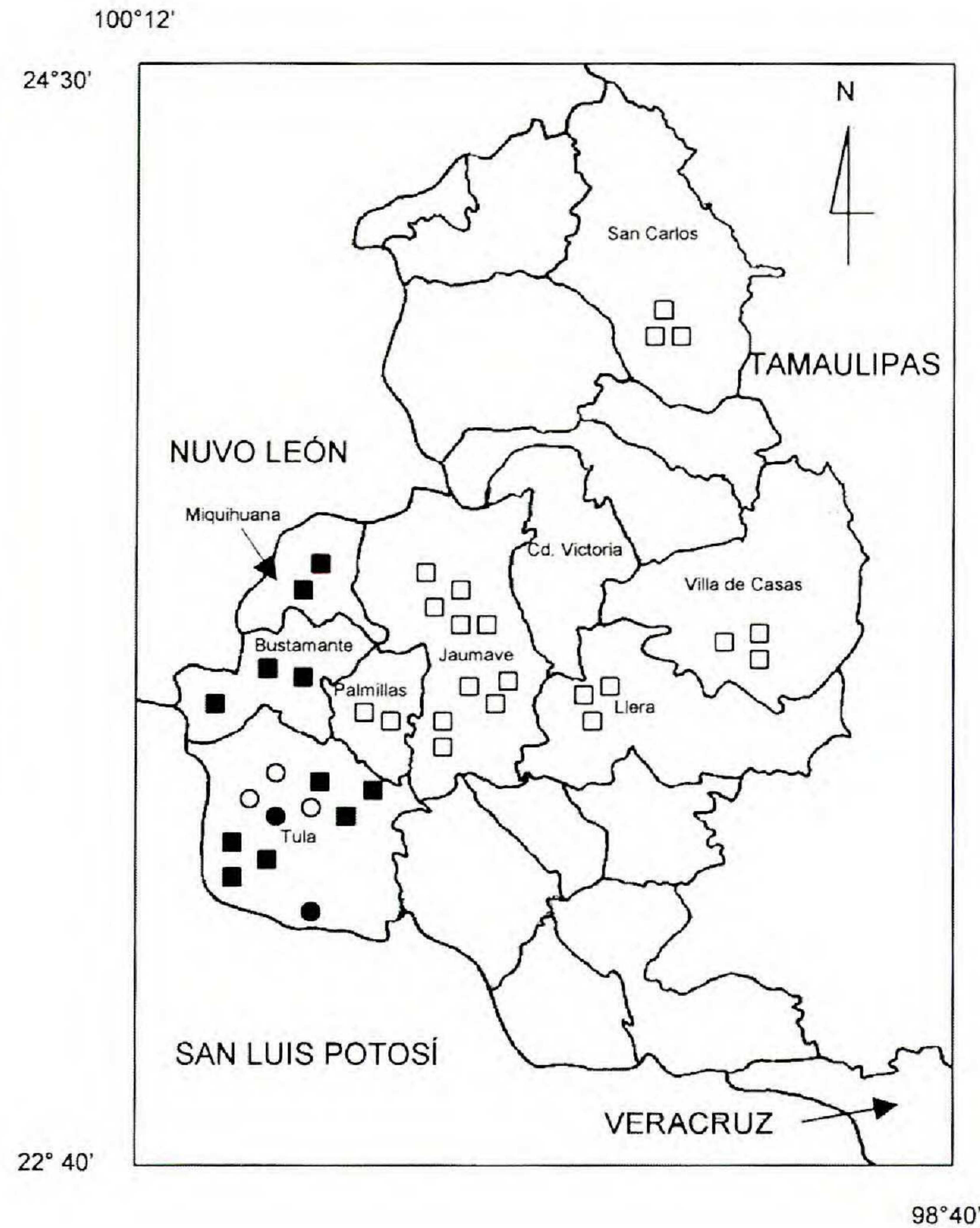


FIG. 1. Map of the state of Tamaulipas, with the distribution of *Ariocarpus* species.

Shumann, *A. fissuratus* (Engelmann) K. Schumann, *A. retusus* Scheidweiler, *Ariocarpus trigonus* Weber, and *A. scaphirostris* Boedeker (Hunt 1992; Hernández & Godínez 1994). Nevertheless in a recent revision of the genus Anderson and Fitz Maurice (1998) added two new subspecies, *A. bravoanus* H. Hernández & E.F. Anderson subsp. *hintonii* E.F. Anderson & Fitz Maurice, and *A. retusus* K. Schumann subsp. *trigonus* (Weber) Scheidweiler based on morphological traits, and hybridizing populations. All taxa are considered threatened or endangered (Anonymous 1991; CITES 1992; UICN 1985; Vovides 1988). The biggest threat to the survival of *Ariocarpus* species is habitat fragmentation due to the removal of natural vegetation in large areas, overgrazing, highway construction, development of urban areas and over-collection of wild populations by commercial and amateur collectors for sale as ornamental plants (Sánchez-Mejorada 1982, 1987; Hernández & Godínez 1994).

The literature published on the genus includes the works by Anderson (1958, 1960, 1961, 1962, 1963, 1964); Bravo (1978), Bravo and Sánchez-Mejorada (1992) and Sánchez-Mejorada (1987).

Only one species of the genus have been studied with an ecological perspective (*Ariocarpus trigonus*) by Suzán et al. (1989) and Martínez et al. (1993).

In Tamaulipas little is known about the distribution and viability of these species because no floristic inventories and demographic studies necessary for the definition of the real status of each species exists to date (Vázquez-Yanes 1979). The main objective of the present study is to document the geographic distribution of the genus *Ariocarpus* in the state of Tamaulipas, México.

METHODS AND MATERIALS

The state of Tamaulipas is located at the northeastern portion of México, bordered by U.S.A. to the north, the States of San Luis Potosí and Veracruz to the south, Gulf of Mexico to the east, and State of Nuevo León to the west. Three major climatic regions according to the Köppen classification modified by García (1964) exist in the state: 1) the central-north region with semi-arid, semi-hot climates, with little annual rainfall (BS1 hw); 2) the southeast region with hot sub-humid or humid climates with summer rainfall (Awo); 3) the south-west region located in the Sierra Madre Oriental with climates ranging from semi-hot sub-humid climates (A) C (W1) (W) to semi-hot humid climates (A) C (m) (w), in an altitude gradient on the eastern slope, and the semi-hot subhumid (A)C(m)(w) to dry semi-hot Bsohw, in an altitude gradient on the western slope (Secretaría de Programación y Presupuesto (SPP) 1985).

The vegetation is dominated by the thorn-forest (north central region), the xerophytic shrubland (south-west region), and tropical deciduous forests (southeast region). In the highlands of the Sierra Madre Oriental, Pine-Oak and Cloud forests are the dominant vegetation types (Table 1) (Marroquín et al. 1964; Rzedowski 1978).

Data were gathered from voucher specimens at the following herbaria: DS, GH, IBUG, K, MEXU, MO, NY, POM-RSA, UAT, US (Holmgren et al. 1981).

TABLE 1. Climatic characteristics of the different municipalities in Tamaulipas where *Ariocarpus* species were detected. Data from Secretaría de Programación y Presupuesto (1985).

Species	Municipality	Vegetation	Soils	Climate	Altitude (m)	Temperature (°c)	Precipitation (mm)
<i>A. agavoides</i>	Tula	Ms	Xk	BSohw	900–1250	21	436
<i>A. kotschoubeyanus</i>	Tula	Ms	Xk	BSohw	1120–1200	21	436
<i>A. retusus</i>	Tula	Mr, Xk	I	Bsohw, BS1hw	1100–1300	21	434
<i>subsp. retusus</i>	Bustamente	Mr, Ch	I, Xk	Cx, BS1kx	1700–1900	17	464
	Miquihuana	Mr, Ch	I, Xk	Bsohx, BS1kx	1600–1900	17	464
<i>A. retusus</i>	Jaumave	Mr, MeT	Bk, I, Xk	BS1hw, Bsohw	600–900	23	469
<i>subsp. trigonus</i>	Palmillas	MeT	Bk, I	(A)C(wo)	1100–1300	19	606
	V. de Casas (San Francisco)	Sbc	Bk	BS1(h)hw, Awo	200–304	24	749
	San Carlos	MeT, M	Bk, Zg	(A)C(wo)	150–190	24	809
	Llera	Sbc	Zg	Awo	350–450	25	789

Ms= submontane shrubland; MeT = tamaulipan shrubland; Mr = century plants shrubland; Ch = chaparral; Sbc = tropical dry forest; M = mesquite forest; Xk = calcic xerosols; Bk = calcic cambisol; I = Litosoil; Zg = Solonchak gleyic; Bsohw = semidry semi-warm; BS1hw = temperate semidry; (A)C(wo) = semi-warm sub-humid with winter rains; BS1(h)hw = semidry warm; Awo = warm sub-humid with winter rains.

Living specimens of *Ariocarpus* were studied in the botanical gardens: Jardín Botánico de la Universidad Nacional Autónoma de México (UNAM); Colección de Cactáceas del Instituto de Ecología y Alimentos (UAT); Jardín Botánico del Instituto Tecnológico de Ciudad Victoria, Tamaulipas (ITCV). Field work was carried out through the state, in order to visit reported sites of *Ariocarpus* occurrence.

RESULTS

In Tamaulipas only three species and two subspecies of the genus were found: *Ariocarpus agavoides*, *A. kotschoubeyanus*, *A. retusus* subsp. *reutus* and *A. retusus* subsp. *trigonus*. Distribution of the species is expressed in Fig. 1. The geographic distribution and characteristics of each species are:

1. *Ariocarpus agavoides* (Castañeda) E.F. Anderson

Common name.—“Magueyito”

Geographic distribution.—San Luis Potosí and Tamaulipas. This species is endemic to the valley of Tula, municipality of Tula, Tamaulipas. The first population reported was located in the north slopes of the city of Tula. However, a new locality was discovered within the valley recently. *Ariocarpus agavoides* inhabit small hills with medium slopes and easily erodable rocky soils (xerosols), in altitudes from 900 m to 1200 m. The associated vegetation in the population located north of Tula were dominated by *Prosopis glandulosa*, *Koeberlinia spinosa* and *Acacia farnesiana*, whereas for the new locality the dominant species were *Hechtia glomerata*, *Agave lecheguilla* and *Agave striata*.

Field observations indicated strong dependence to nurse plants, low recruitment and pollination dependent on bees. The type locality is extremely perturbed by a waste disposal and overgrazing. Signs of plant extraction were detected several times.

Cited specimens: **MEXICO. Tamaulipas:** Tula, 1200 m, *Castañeda s.n.* (DS); Tula, 1200 m, *Cowper 1957* (POM); Tula, 1200 m, *Anderson 1616*, (GH, K, MO, NY, POM).

Specimens examined: **MEXICO. Tamaulipas:** Tula, 1200 m, *Bravo s.n.* (MEXU); Tula, 1170 m, *Hernández et al. 2054* (MEXU); Tula, 1240 m, *Scheinvar & Sánchez-Mejorada 750* (MEXU); Tula, 1200 m, *Sánchez-Mejorada 750* (Jardín UNAM); Tula 1200 m, *Hernández* (Jardín ITCV); Tula, 1200 m, *Martínez-Avalos & Jiménez 0441* (UAT); Tula, 914 m, *Martínez-Avalos 0446* (UAT).

2. *Ariocarpus kotschoubeyanus* (Lemaire) K. Schumann

Common names.—“Pezuña de venado,” “Pata de venado”

Geographic distribution.—Tamaulipas, Nuevo León, Zacatecas, San Luis Potosí and Querétaro. This species is reported for Tamaulipas in two sites in Tula, located northeast of Tula City (1200 m). The species grows in rocky soils, with poor organic material (xerosols), and inhabit medium slopes in a desert shrubland (Rzedowski 1978) dominated by *Agave lecheguilla*, *A. striata*, *Hechtia glomerata* and *Dasyllirion longissimum*.

We detected a well-preserved locality (location concealed for conservation purposes), with populations represented in different size classes. Sites close to Tula City exhibited heavy habitat disturbance by overgrazing and over-collection of plants.

Cited specimens (Anderson 1960, 1963): **MEXICO. Tamaulipas:** Tula 1200 m, *Albert 1959* (POM, US); Tula, *Anderson 1617* (POM, US)

Examined specimens: **MEXICO. Tamaulipas:** Tula, 1190 m, *Anderson 1738* (MO); Tula, *Arreola 736* (IBUG); Tula, *Scheinvar et al. 4070* (MEXU); Tula, 1200 m, *Martínez-Avalos 091* (UAT); Tula, 1127 m, *Martínez-Avalos 0437* (UAT).

3. *Ariocarpus retusus* K. Schumann subsp. ***retusus*** (Scheidweiler) E.F. Anderson & Fitz Maurice

Common names.—“Chaute,” “Chautle”

Geographic distribution.—Tamaulipas, Coahuila, Nuevo León, San Luis Potosí y Zacatecas. In Tamaulipas it is common in the municipalities of Miquihuana, Bustamante, Tula and Palmillas. This species grows over hills and rocky slopes with clustered populations at altitudes from 700 to 2100 m, in a desert shrubland (Rzedowski 1978), dominated by *Agave lecheguilla*, *A. striata*, *Dasyllirion longissimum*, *D. texanum* and *Yucca carnerosana*.

Populations of *A. retusus* subsp. *retusus* inhabit also perturbed areas dominated by *Dodonea viscosa*, in small canyons. Hybridizing specimens with *A. retusus* subsp. *trigonus* were found in eastern slopes of “El Cielo Biosphere Reserve.” Populations were also detected in pinyon pine forests dominated by *Pinus nelsonii* and *Pinus cembroides* in Miquihuana.

Cited specimens (Anderson 1964): **MEXICO. Tamaulipas:** Miquihuana, 1900 m, *Cowper 1889, 1958* (POM, US); Tula, 1200 m, *Anderson 1964* (POM, US).

Specimens examined: **MEXICO. Tamaulipas:** Bustamante, 1700 m, *Hernández et al. 2029* (MEXU); Bustamante, 1590 m, *Hernández et al. 2033* (MEXU); Bustamante, 2000 m, *Jiménez 0018* (UAT); Miquihuana, 1524 m, *Martínez-Avalos 054* (UAT); Miquihuana, 1487 m, *Martínez-Avalos 0151* (UAT); Tula, 1250 m, *Martínez-Avalos 0664* (UAT).

4. *Ariocarpus retusus* K. Schumann subsp. ***trigonus*** (Weber) E.F. Anderson & Fitz Maurice

Common name.—“Chaute,” “Chautle”

Geographic distribution.—Tamaulipas and Nuevo León. This species is distributed in the municipalities of Jaumave, Palmillas, San Carlos, Villa de Casas and Llera de Canales. The populations inhabit areas from 250 m to 1400 m, in different soil types. The centre of the distribution is the Jaumave Valley (Martínez-Avalos et al. 1993).

Field observations indicate an ability to survive in exposed and eroded soils, A survey in the Jaumave Valley indicated 11 sub-populations with approximately 35,000 individuals. The plants exhibited a non-exclusive cactus-nurse plant relationship. The most important nurses were *Prosopis laevigata* and *Cercidium praecox*. Plants beneath healthy nurses exhibited better conditions than those with damaged nurses (and with smaller canopies). *A. trigonus* plants are able to thermo-regulate in open sun but individuals beneath the shade of nurses exhibited better thermo-regulation (Suzán unpublished data).

Cited specimens (Anderson 1964): **MEXICO. Tamaulipas:** Jaumave Valley, 760 m, *Anderson 1580* (POM, US, NY, MO, GH, K); Jaumave Valley, 760 m, *Meyer & Rogers 3115* (MO, US); E of San Vicente, Jaumave Valley, 760 m, *Anderson 1089* (POM, US, NY, MO, GH); W of Cd. Victoria, 700 m, *Anderson 1153, 1708* (POM, US).

Specimens examined: **MEXICO. Tamaulipas:** W of San Antonio, 676 m, *Arreola* 275 (IBUG); NE of Tula, *Sánchez-Mejorada* 2070 (MEXU); Jaumave 750 m, *Hernández et al.* 2038 (MEXU); Jaumave, 750 m, *Hernández* 2047 (MEXU); Valle de Jaumave, 610 m, Martínez-Avalos 068 (UAT); Villa de Casas, 304 m, Martínez-Avalos 0383 (UAT); San Carlos, 189 m, Martínez-Avalos 541 (UAT); San Carlos, 400 m, Martínez-Avalos 0745 (UAT).

DISCUSSION

It's difficult to determine the ecological requirements that affects the geographic distribution of the genus *Ariocarpus* with the analysis of herbarium specimens, and even with field studies in the Chihuahuan Desert in México (Anderson 1958, 1961). In Tamaulipas this genus is restricted to the Chihuahuan Desert region, the Tamaulipan arid zone (Tamaulipas biotic province) and some specific tropical neighboring areas with similar climatic parameters (i.e. Llera Valley) (Fig. 1). The area in Tamaulipas where *Ariocarpus* grows is similar habitats in the neighboring states of Nuevo León and San Luis Potosí.

The genus is distributed in altitudinal gradients from 200 to 2100 m (Table 1). Of the three species in the state, *A. retusus* subsp. *trigonus* shows the widest range in distribution, inhabiting different types of vegetation, soils and climate in the southwestern, central and southern parts of the state. *Ariocarpus agavoides* has the most restricted distribution in an area smaller than 2 km², being the species most highly disturbed due to direct and indirect factors such as habitat destruction for garbage incineration, marked hydric soil erosion, overgrazing, and excessive over-collection of individuals (Hernández 1992; Sánchez-Mejorada 1987). *Ariocarpus kotschoubeyanus* is a difficult species to find in the field due to its size and form; therefore, the true size of wild populations is relatively unknown. *Ariocarpus retusus* subsp. *retusus* inhabits the southwestern arid zones of the state and is well-adapted to the Chihuahuan Desert region.

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